Evolving Artificial Pain from Fault Detection through Pattern Data Analysis

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Abstract— **Fault detection is a classical area of study in robotics and extensive research works have been dedicated to investigate its broad applications. As the breath of robots applications requiring human interaction grow, it is important for robots to acquire sophisticated social skills such as empathy towards pain. However, it turns out that this is difficult to achieve without having an appropriate concept of pain that relies on robots being aware of their own body machinery aspects. This paper introduces the concept of pain, based on the ability to develop a state of awareness of robots own body and the use of the fault detection approach to generate artificial robot pain. Faults provide the stimulus and defines a classified magnitude value, which constitutes artificial pain generation, comprised of synthetic pain classes. Our experiment evaluates some of synthetic pain classes and the results show that the robot gains awareness of its internal state through its ability to predict its joint motion and generate appropriate artificial pain. The robot is also capable of alerting humans whenever a task will generate artificial pain, or whenever humans fails to acknowledge the alert, the robot can take a considerable preventive actions through joint stiffness adjustment.**

type of fault is detected, it merely functions as a stimulus to activate the new motion plan or new motion behaviour generation. Unlike in robots, in human mechanism, any machinery of body failure will generate internal states where humans experience what is called 'pain' [12]. In fact, if the faults in robots themselves are associated with not only stimulus but also specific meaningful magnitude, it will be beneficial for robots to incorporate them as part of their experience. This paper intends to derive machinery faults of the robots, detected from robot proprioceptive sensors, into an appropriate representation of pain by introducing an artificial pain concept containing synthetic pain classification. This paper provides experimental results by presenting different scenarios to evaluate each of synthetic pain classification proposals.

The reminder of the paper proceeds as follows: section II gives an overview of proposed artificial pain concept, including description of the proposed synthetic pain and